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AUTHOR Vicino, Frank L.
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ABSTRACT

This paper outlines the design and use of two linear models as decision-making tools in a school district. The problem to be solved was the allocation of resources for both clerical and custodial personnel. A solution was desired that could be quantified and documented and objectively serve the needs of the district. A clerical support model was designed using the factors of student discipline and motivation level, student size and activity level, transportation and school area, and personnel. The same procedure was used in the design of the custodian allocation model using the factors of work distribution, work area, student activity, and cafeteria/kitchen status. For both models, measures were used to quantify the factors. The factors and measures were presented to a body of district judges to determine factor weights. Then the measures were transformed to standard scores resulting in indices that could have general application in any school district. A custodial cost rating was devised by dividing the total custodial salaries by the school work level index in order to compare the schools in terms of custodial cost effeciency. (Author/MLF)

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THE USE OF LINEAR MODELS FOR DETERMINING SCHOOL WORKLOAD AND ACTIVITY LEVEL

Dr. Frank L. Vicino

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In Paul Meehl's book Clinical Versus Statistical Prediction: A Theoretical Analysis and a Review of the Evidence (1954) studies were reviewed showing that the prediction of numerical criterion variables of psychological interest from numerical predictor variables is better done by a proper linear model than by judgment by experts. Recently Rolyn Daves in the American Psychologist (July 1979) presents evidence showing that even improper linear models may be superior to expert predictions. Daves classifies improper models as those in which the parameters are quantified but the weights of the predictor variables are obtained by some nonoptimal method; for example, by judgment. The present paper outlines the use of two such models as a decision making tool in an education setting.

Both cases were initiated by the need for the Superintendency to make personnel allocation decisions which had widespread budget affects. Rather than to trust their subjective response and then possibly to incur the wrath of interested subpublics, they asked for a solution which could be made quantified, documented and more objectively serve the needs of the district.

The two models presented here were designed to answer the following two general questions:

1. The Clerical Support Allocation Model. How much, and how should clerical support be allocated to each of the district's elementary schools?

2. The Custodian Allocation Model. How many custodians should be allocated to each of the district schools?

Obviously, answers to both questions must be based on needs, and needs are based on requirements. A set of linear models were designed to incorporate as many of the factors needed to answer questions of need and requirements. The following sections outline the design and use of the models.

THE CLERICAL SUPPORT ALLOCATION MODEL

Rather than to allow the superintendency to determine on the basis of their subjective, albeit expert, opinion on how much clerical support should be allocated to the district's elementary school, a linear model was designed. When the major factors which appear to affect the general school administrative workload were examined, they appeared to fall into four main categories (Fig. 1). Therefore:

$$\text{General School Workload} = f[\text{Student Body Size \& Activity}] + f[\text{Student Discipline and Motivational Level}] + f[\text{Transportation and School Area}] + f[\text{Personnel}]$$

The following measures were used to quantify the four factor (Table I). In addition, the factors and measures were presented to a body of district judges (superintendency and principals) to determine factor weights (Table I).

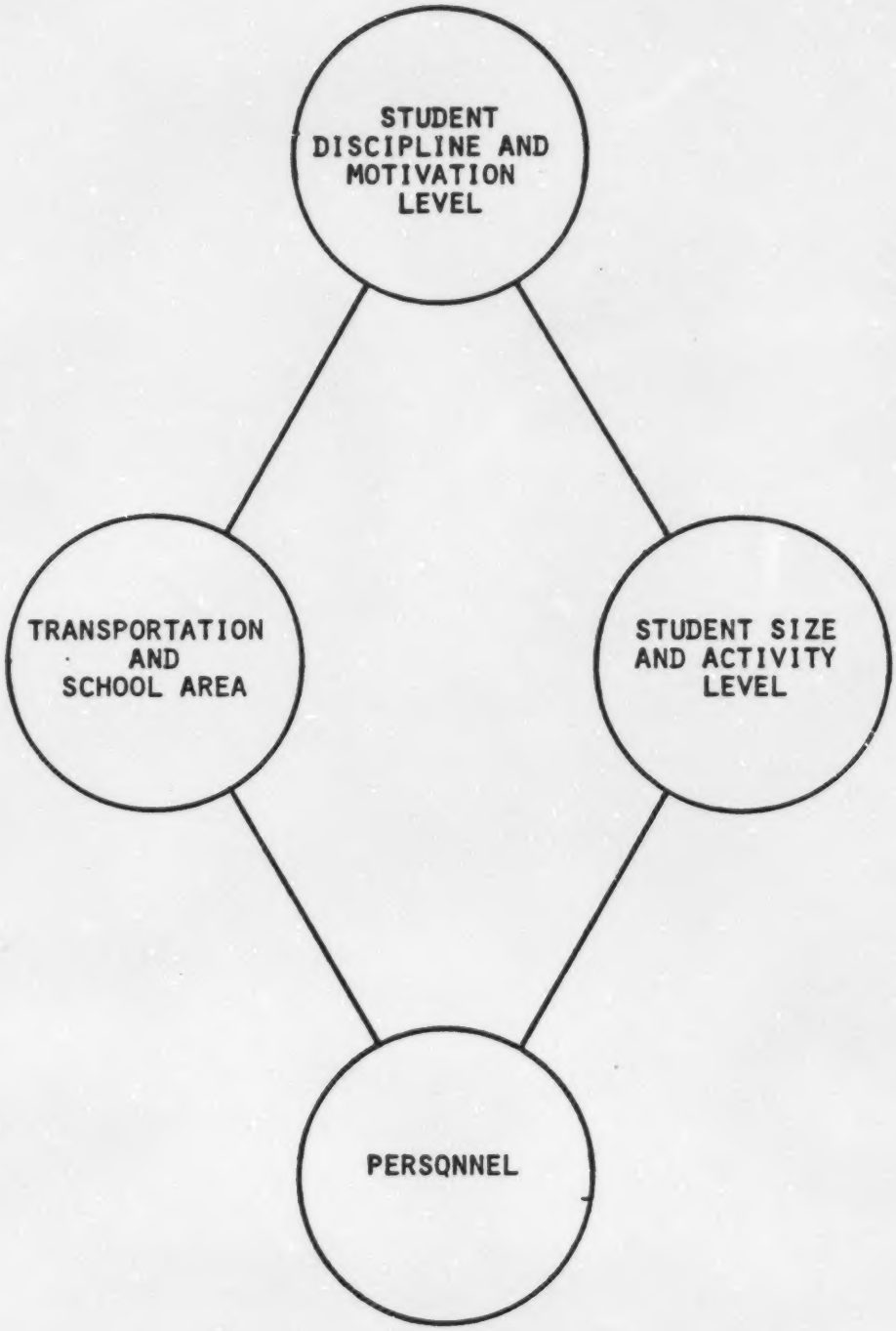
STUDENT DISCIPLINE AND MOTIVATION LEVEL
TRANSPORTATION AND SCHOOL AREA
STUDENT SIZE AND ACTIVITY LEVEL
PERSONNEL

FIG. 1

Table I

Model Parameters

Factors	Measurements	Factor Weights
1. Student Body Size and Activity	Student Transactions	5.5
2. Student D & M Level	Absence Rate	1
	Vandalism (Cost/Child)	1
3. Transportation and School Area	No. of Students Transported	1
	School Area (Square Miles)	1/2
4. Personnel	No. of Personnel	1
	Teacher Absence Rate	1

Then the measures were:

1. Transformed to Z (standard) scores, and
2. Totaled

Resulting with the following model:

$$\text{School Activity Index (SAI)} = 5.5\left[\text{Student Transactions (S.T.)}\right] + \text{Absence Rate (A.R.)} + \text{Vandalism (V.)} +$$

$$\text{Pupils Transported (P.T.)} + \frac{\text{School Area (S.A.)}}{2} + \text{No. of Personnel (P.)} +$$

$$\text{Teacher Absence Rate (T.A.)}$$

After Z scores were determined for each of the school measures the following transactions were performed:

1. Standard scores were totaled with factor weights
2. The total was then multiplied by ten (10) and then 100 added.

Therefore:

$$SAI = 10\left[5.5ST_Z + AR_Z + V_Z + PT_Z + 1/2SA_Z + P_Z + TA_Z\right] + 100$$

Table 1 presents the SAI scores for each of the elementary schools examined, with higher scores exhibiting greater school activity.

Figure 2 graphically displays the distribution of school activity levels among schools.

In order to allocate resources (hourly clerical support) the schools were:

1. placed in five clusters (levels A-F) according to SAI level (Fig. 2),
2. weights were given each cluster according to the mean SAI level for that cluster; and
3. finally hourly clerical support was allocated on the basis of the weights given each cluster.

Table 1
STANDARD SCORES FOR SCHOOL FACTORS
1976-77

School	Student Trans-actions*	Trans-portation	School Area**	Van-dalism	Absence Rate	Teachers/ Support	Teacher Absence	School Act. Index Total
Adams	2.199	-0.61	-0.23	-0.68	-0.03	-0.00	1.84	124.89
Edison	-1.319	-1.10	-0.22	0.32	-1.15	-0.14	-0.63	57.61
Eisenhower	12.592	-0.34	-0.20	-0.27	0.43	0.68	-0.70	223.84
Emerson	-3.464	-0.94	-0.21	0.14	-1.31	-0.14	0.25	43.26
Field	-1.979	-0.27	-0.05	-0.85	-1.51	-0.83	0.29	48.01
Franklin	-12.207	-0.46	-0.13	3.73	1.87	-2.07	-1.85	-11.17
Hale	0.439	0.46	0.40	-0.71	-0.67	0.54	-0.56	138.50
Hawthorne	2.034	-0.25	-0.21	-0.24	-1.63	-0.97	0.21	89.44
Holmes	1.429	-1.03	-0.24	-0.34	0.75	-0.55	0.51	105.29
Jefferson	5.993	1.78	0.17	-0.30	0.43	-0.28	-1.33	164.63
Keller	-1.594	2.10	-0.22	-0.88	1.55	-0.97	-0.11	98.76
Lehi	-1.924	1.07	0.14	-0.75	2.34	-0.97	1.36	112.66
Lincoln	-1.154	-1.09	-0.24	-0.49	-0.35	0.54	-0.07	71.46
Lindbergh	-5.553	-0.49	-0.24	-0.47	-0.19	0.13	-0.78	24.07
Longfellow	13.362	0.18	-0.03	-0.68	-0.35	0.82	-0.82	224.82
Lowell	-2.199	-0.81	-0.23	0.20	0.43	1.92	0.99	64.61
Redbird	6.873	-0.14	0.15	-0.39	-0.03	0.54	1.25	182.53
Roosevelt	4.949	-1.09	-0.23	-0.78	-0.99	1.37	-0.52	127.99
Salk	1.044	1.97	2.31	-0.66	0.12	0.40	-1.30	138.84
Stevenson	-0.549	-0.12	0.08	1.50	1.07	-0.55	0.40	118.31
Taft	-1.924	-0.18	-0.11	1.18	1.07	-0.69	-0.19	91.56
Washington	-1.649	1.76	-0.12	-0.53	-0.67	-0.55	-0.22	80.21
Webster	-1.869	-0.34	-0.00	0.63	-0.35	0.13	2.17	103.81
Whitman	4.674	0.84	-0.15	0.73	-0.67	2.61	0.91	189.44
Whittier	-12.592	-0.85	-0.15	0.62	-1.15	-0.97	-1.07	-61.62

*Weighted by a factor of 5.5.
**Weighted by a factor of 1/2.

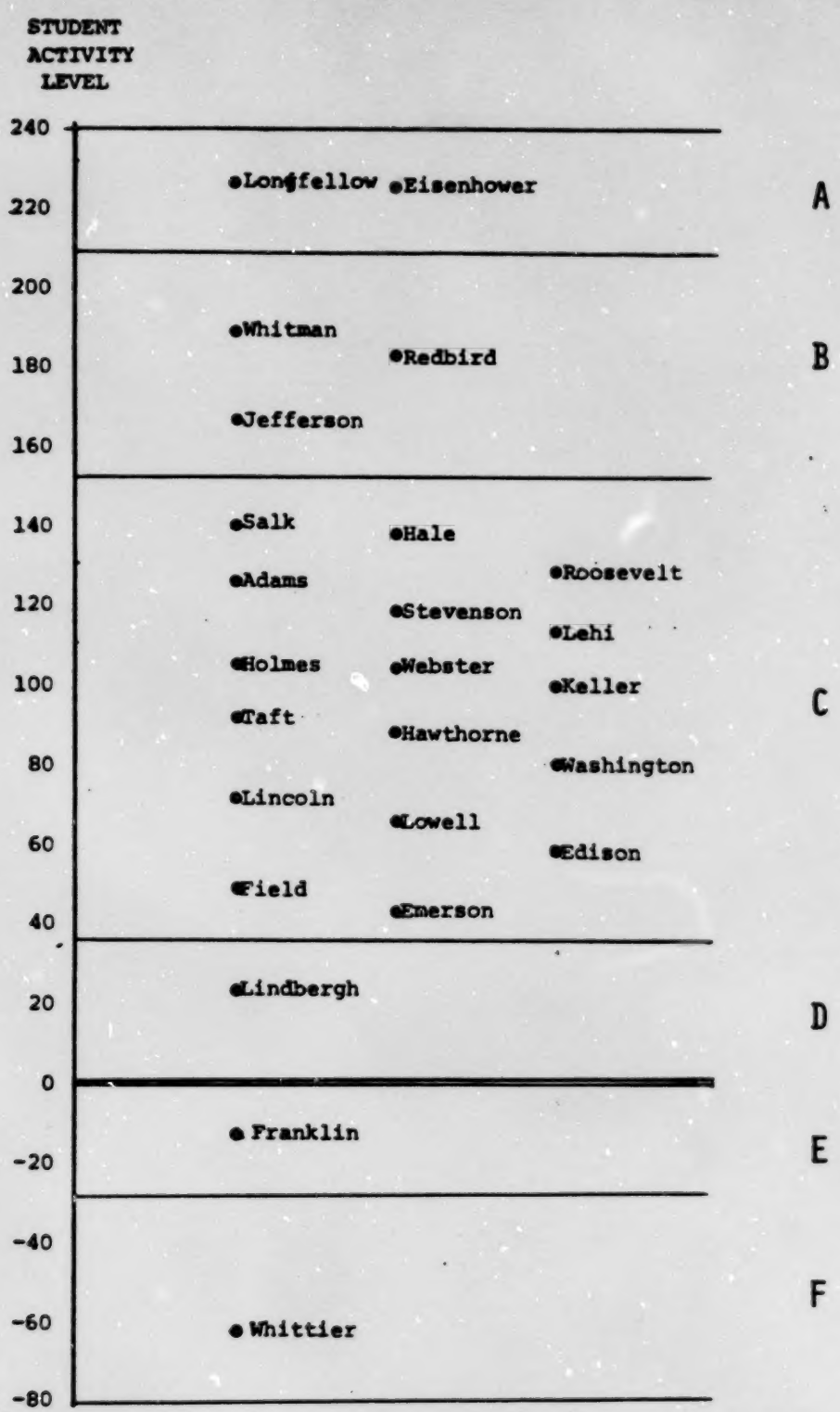

Fig. 2 - School Activity Levels
(Elementary)

The Custodian Allocation Model

The old philosophical question "How many angels can you put on the head of a pin?" has been replaced by an updated, less philosophical but almost as perplexing a problem -- "How many custodians should you put in a school?"

The model presented here is an attempt to present a formula or standard that could have general application in any school district.

After the major factors associated with custodial workload were examined a linear model was designed to estimate a Work Level Index. The following factors, along with the measures and weights, were used in the determination of the Work Level Index.

Factor	Measure	Weights
Work Distribution	Number of Rooms	1/12
Work Area	Square Footage	1/15,000
Student Activity	Number of Students	1/225

In addition to the above a moderator factor was added--as to whether the school had a cafeteria/kitchen with:

a. Cafeteria area with no kitchen (+.1)

b. Cafeteria area with kitchen (+.3)

c. No cafeteria area or kitchen (0)

The factor weights were determined by standardizing the three levels on the basis of establishing the level of the factor which can be accommodated by one custodian, i.e., one custodian can generally take care of 12 rooms, 15,000 square feet or a school of approximately 225 students. These mean levels were extrapolated from the literature and serve as the judgmental weighting system.

After weighting and adding the three major factors, the figure was divided by three and the moderator variable was added. The resulting figure was then multiplied by one hundred (100) to produce the Work Level Index.

$$\text{Work Level Index} = \left[\frac{\frac{\text{Square Footage}}{15{,}000 \text{ sq. ft.}} + \frac{\text{Number of Rooms}}{12} + \frac{\text{Number of Students}}{225}}{3} + \text{Cafe/Kitchen Factor} \right] \times 100$$

This index can now be used to examine the relative work level between various schools in the district. In this way, one school could be directly compared to another in terms of work effort or load. Now, obviously general work load should be related to custodian cost; that is, schools requiring more work require more cleaning, hence either more custodians or more work hours or both. If this measure of work load is directly related to custodian cost, the relative distribution of custodial services within our school district would appear appropriate. If, however, there proved to be some schools equal in terms of work load but differing considerably in custodial costs, then there is an inequity in the distribution of custodial services, and at that point one must examine the possible presence of other factors (programs, conditions, actual work tasks, etc.). If no major differences in other factors are found and the less costly school (in terms of custodial services) appears to be kept clean and healthful, then one must question service cost at the school(s) with greater custodial costs for the equivalent work load(s).

Cost Rating

In order to compare the schools in terms of custodial cost efficiency a Cost Rating was devised incorporating the Work Level and Custodial Salaries as a measure of cost. Although Custodial Salaries does not represent the total cost of custodial services, it can serve well in discussing relative costs between schools (especially since in our case, of the $1.4 million cost for custodial services, $1.3 million is for personnel costs). This custodial cost rating was devised by dividing the total custodial salaries by school work level index (the major cost factor):

$$\text{Cost Rating} = \frac{\text{Custodial Cost (Salaries)}}{\text{Work Level Index}}$$

Therefore, a high cost rating shows that for the amount of money spent (salaries) less work is being accomplished than a school with a low cost rating.

The initial information concerning work level and cost efficiency will serve as basic data for a series of steps which offer alternative recommendations concerning work allocation. If the assumption can be made that if the school which shows the lowest cost rating is considered maintained in a clean and sanitary condition then we could expect the same or at least similar efficiencies at other schools, conditions permitting.

The following table (Table I A, B) presents the major factors used to determine custodial work level and cost efficiency of each of the schools. We have numbered the schools in the table rather than use names, but the figures are bona fide.

Table I

WORK LEVEL AND COST RATING

A. Elementary Schools

Schools	Kitchen/ Cafeteria	Square Feet	No. Students	No. Rooms	Custodial Cost (Salaries)	Work Level	Cost Rating	Rank
E-1	1	38,697	732	82	21,494	432	50	16.5
E-2	3	39,111	797	70	23,435	429	55	10
E-3	1	77,657	500	60	21,706	423	51	14.5
E-4	1	27,471	588	47	21,612	288	75	4
E-5	1	43,800	554	62	19,310	362	53	11.5
E-6	0	37,373	274	67	18,806	310	61	7
E-7	1	36,315	680	58	21,887	353	62	6
E-8	1	37,224	743	82	21,275	431	46	20
E-9	1	55,500	674	99	21,381	508	42	23
E-10	1	24,500	269	34	16,424	198	83	2
E-11	3	39,641	584	82	20,315	447	45	21.5
E-12	1	22,514	361	34	18,469	208	89	1
E-13	3	37,659	658	81	23,283	436	53	11.5
E-14	1	77,657	880	60	21,381	480	45	21.5
E-15	1	38,216	843	82	21,612	448	48	19
E-16	1	29,572	547	54	20,525	307	67	5
E-17	1	43,800	796	77	21,381	384	56	9
E-18	1	77,657	750	60	22,897	461	50	16.5
E-19	1	77,657	648	50	25,765	445	58	8
E-20	1	32,072	531	57	25,191	318	79	3
E-21	3	37,509	580	80	21,491	422	51	14.5
E-22	1	42,049	735	71	21,494	410	52	13
E-23	1	41,544	614	82	20,684	421	49	18

Table I (Continued)

B. Junior High Schools

School	Kitchen/ Cafeteria	Square Feet	No. Students	No. Rooms	Custodial Cost (Salaries)	Work Level	Cost Rating	Rank
JH-1	3	77,403	1,159	177	48,527	860	56	4
JH-2	1	61,168	1,096	120	52,181	642	81	1
JH-3	3	90,243	967	176	48,505	863	56	4
JH-4	3	57,561	1,250	154	46,012	770	60	2
JH-5	3	110,900	1,050	173	50,836	912	56	4
JH-6	3	106,976	1,349	185	49,142	981	50	6

The work level variability between the schools (Elementary 198-508 and Junior High 642-981) is not surprising since the schools exhibit major differences in architecture, age, and number of students. The extent of variation in terms of cost ratings (Elementary 42-89 and Junior Highs 50-81), however, is surprising.

In some cases there are schools with relatively low work levels (i.e., E-20 318) and fairly high custodial costs ($25,191). There are others with high work levels (i.e., E-9 508) and relatively low custodial costs ($21,381). This discrepancy is even more pronounced in the junior high schools (Table I B). Junior High School-6 shows the highest work level (981) with a relatively low custodial cost ($49,142), whereas JH-2 with the lowest work level (642) exhibits the greatest cost ($52,181).

In order to examine the possible reduction in cost and therefore increase in efficiency, the potential savings can be computed in two different ways.

Table II A, B presents the actual costs, projected costs (based on computing all schools with the cost rating of the most efficient school) and the accompanying savings for our district.

Via this method a total savings of $165,822 in custodial cost for the elementary and junior high schools was determined. Since there may be other factors not accounted for in the formula associated with some of the schools that reflect high cost ratings these savings could only be classified as maximum.

TABLE II

PROJECTED SAVINGS
A. Elementary Schools

Schools	Actual Cost	Projected Costs	Savings
E-1	$ 21,494	$ 18,144	$ 3,350
E-2	23,435	18,018	5,417
E-3	21,706	17,766	3,940
E-4	21,612	12,096	9,516
E-5	19,310	15,204	3,926
E-6	18,806	13,020	5,786
E-7	21,887	14,826	7,061
E-8	21,275	18,102	3,173
E-9	21,381	21,381	---
E-10	16,424	8.316	8,108
E-11	20,315	18,774	1,541
E-12	18,469	8,736	9,733
E-13	23,283	18,312	4,971
E-14	21,381	20,160	1,221
E-15	21,612	18,816	2,796
E-16	20,525	12,894	7,631
E-17	21,381	16,128	5,253
E-18	22,897	19,362	3,535
E-19	25,765	18,690	7,075
E-20	25,191	13,356	11,835
E-21	21,491	17,724	3,767
E-22	21,494	17,220	4,274
E-23	20,684	17,682	3,002
Total Elem.	$491,818	$374,907	$116,911

Table II (Continued)

B. Junior High Schools

Schools	Actual Cost	Projected Costs	Savings
JH-1	$ 48,527	$ 43,000	$ 5,527
JH-2	52,181	32,100	20,081
JH-3	48,505	43,150	5,355
JH-4	46,012	43,700	2,312
JH-5	50,836	35,200	15,636
JH-6	49,142	49,142	---
Total Jr. High	$295,203	$246,292	$ 48,911
GRAND TOTALS	$787,021	$621,199	$165,822